

Science Curriculum Analysis Worksheet

Current research on science education emphasizes the importance of integrating the learning progressions from all three dimensions included in *A Framework for K-12 Science Education* in order to deepen student understanding of the big ideas connected to scientific phenomena. This Curriculum Analysis Worksheet is a tool that can be used to align your current instructional practices to a 3-dimensional model of instruction, designed to deepen student learning.

1.	Identify a science concept or concepts within the Arizona Science Standard from Strands 4, 5, or 6 that you teach at your grade level/course. Fill in the title of the science concept at the top of the worksheet.
2.	Identify learning progressions from each of the three dimensions that will be bundled together to build student conceptual understanding of the science concept(s) selected in Step 1.
3.	<ul style="list-style-type: none"> a. Identify objectives from the Arizona Science Standard from Strands 1, 2 and 3 that align with the Science and Engineering Practices learning progression(s) you have identified in Step 2. b. Examine your current science curriculum to identify ways you can modify instruction to reach the vision of <i>A Framework for K-12 Science Education</i> while you currently teach grade level objectives aligned to the Arizona Science Standard.
4.	<ul style="list-style-type: none"> a. Identify the current objectives from the Arizona Science Standard from Strands 4, 5, and 6 that align with the Disciplinary Core Ideas learning progression(s) you have identified in Step 2. b. Examine your current science curriculum to identify ways you can modify instruction to reach the vision of <i>A Framework for K-12 Science Education</i> while you currently teach grade level objectives aligned to the Arizona Science Standard.
5.	<ul style="list-style-type: none"> a. Identify the current unifying concept(s) from page viii of the Arizona Science Standard that aligns with the Crosscutting Concepts learning progression(s) you have identified in Step 2. b. Examine your current science curriculum to identify ways you can modify instruction to reach the vision of <i>A Framework for K-12 Science Education</i> while you currently teach grade level objectives aligned to the Arizona Science Standard.
6.	<ul style="list-style-type: none"> a. Identify connections to grade level ELA/Literacy standards, as appropriate. b. Identify connections to grade level Mathematics standards and practices, as appropriate.

1. Arizona Science Concept: Strand 5 Concept 2: Force and Motion

Big Idea/Scientific Phenomenon:

The total amount of energy in the Universe is always the same but can be transferred from one energy store to another during an event.

- Energy can be transferred from one form to another such as potential to kinetic but it will always be conserved.

2. Science and Engineering Practices Learning Progression

(See Learning Progressions for 6-12 Science)

Developing and Using Models

Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.

Planning and Carrying Out Investigations

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Using Mathematics and Computational Thinking

Create a computational model or simulation of a phenomenon, designed device, process, or system.

Disciplinary Core Ideas Learning Progression

(See Learning Progressions for 6-12 Science)

PS3: Energy

- Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.
- At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.
- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.
- The availability of energy limits what can occur in any system.

Crosscutting Concepts Learning Progression

(See Learning Progressions for 6-12 Science)

Systems and System Models

Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Energy and Matter

Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.

Three Dimensional Learning Outcome:

- Create a model to demonstrate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

3. Science and Engineering Practices

Current Practice	<p>Identify performance objectives from Strands 1-3 within the Arizona Science Standard that align to the learning progressions listed above. (Strand 1: Inquiry; Strand 2: History and Nature of Science; Strand 3: Science and Social Perspectives)</p> <p>Concept 1: Observations, Questions, and Hypotheses Formulate predictions, questions, or hypotheses based on observations. Evaluate appropriate resources. PO 1. Evaluate scientific information for relevance to a given problem. PO 2. Develop questions from observations that transition into testable hypotheses. PO 3. Formulate a testable hypothesis. PO 4. Predict the outcome of an investigation based on prior evidence, probability, and/or modeling (not guessing or inferring).</p> <p>Concept 2: Scientific Testing (Investigating and Modeling) Design and conduct controlled investigations. PO 1. Demonstrate safe and ethical procedures (e.g., use and care of technology, materials, organisms) and behavior in all science inquiry. PO 2. Identify the resources needed to conduct an investigation. PO 3. Design an appropriate protocol (written plan of action) for testing a hypothesis: <ul style="list-style-type: none"> • Identify dependent and independent variables in a controlled investigation. • Determine an appropriate method for data collection (e.g., using balances, thermometers, microscopes, spectrophotometer, using qualitative changes). • Determine an appropriate method for recording data (e.g., notes, sketches, photographs, videos, journals (logs), charts, computers/calculators). </p> <p>PO 4. Conduct a scientific investigation that is based on a research design. PO 5. Record observations, notes, sketches, questions, and ideas using tools such as journals, charts, graphs, and computers.</p> <p>Concept 3: Analysis, Conclusions, and Refinements Evaluate experimental design, analyze data to explain results and propose further investigations. Design models. PO 1. Interpret data that show a variety of possible relationships between variables, including: positive relationship, negative relationship or no relationship PO 2. Evaluate whether investigational data support or do not support the proposed hypothesis. PO 4. Evaluate the design of an investigation to identify possible sources of procedural error, including: sample size, trials, controls, analyses</p> <p>Concept 4: Communication Communicate results of investigations. PO 1. For a specific investigation, choose an appropriate method for communicating the results. PO 2. Produce graphs that communicate data. PO 3. Communicate results clearly and logically. PO 4. Support conclusions with logical scientific arguments.</p>	Vision of A Framework for K-12 Science Education	<p>Gap Analysis/Curriculum Examination Refer to the Science and Engineering practice learning progressions within the Learning Progressions for 9-12 Science document and your current curriculum to answer the following questions.</p> <ul style="list-style-type: none"> • What practices are currently missing from my curriculum? • What changes and refinements need to be made? • What strategies/investigations can be implemented to achieve the vision? <p>Engage: Observe a swinging pendulum or a video of a swinging pendulum. Ask students: How would you define a pendulum? What are the parts and how does it work? What variables affect the rate of a pendulum swing? How does the force of gravity on the Moon compare with the force of gravity on Earth? What effect do you think the difference in gravitational forces would have on this pendulum?</p> <p>Explore: Have students devise an experiment that tests the variables, including mass of object, length of string or wire, and/or starting angle, associated with a pendulum. Collect data to determine the effect that each variable has on the period of the pendulum. Ask students to think about these questions: How do you get the longest swing? How do you get the fastest swing?</p> <p>Explain: Use the data collected from the student created experiment and teacher demonstration to provide an evidence-based explanation (Claim – Evidence - Reasoning) about the operation of a swinging ship amusement park ride and how that would change if it was relocated on the Moon.</p> <p>Extend: Have students design a set up with two pendulums that allow them to swing back and forth to see if the motion of one influences the other.</p>
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4. Disciplinary Core Ideas

<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Current Performance Objectives</p>	<p>Strand 5 Concept 2 Motions and Forces Analyze relationships between forces and motion.</p> <p>PO 3. Explain how Newton’s 1st Law applies to objects at rest or moving at constant velocity.</p> <p>PO 9. Represent the force conditions required to maintain static equilibrium.</p> <p>PO 10. Describe the nature and magnitude of frictional forces.</p> <p>PO 11. Using the Law of Universal Gravitation, predict how the gravitational force will change when the distance between two masses changes or the mass of one of them changes.</p>	<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Vision of A Framework for K-12 Science Education</p>	<p>Gap Analysis Refer to the Content learning progressions within the Learning Progressions for 9-12 Science document and your current curriculum to answer the following questions.</p> <ul style="list-style-type: none">• What core idea(s) is/are currently targeted within my current curriculum?• What changes and refinements need to be made? (add, refine, delete concepts)• What strategies/investigations can be implemented to achieve the vision? <ol style="list-style-type: none">1. Have students conduct Newton’s law experiments including force tables and frictional force activities.2. Have students complete a Fulcrum activity to understand the concept of static equilibrium.3. Use the pHet simulations on pendulums for students to be able to change variables after completion of their own experiments to collect additional information if needed.4. Have student complete an Energy Analysis answering the following question – How are kinetic energy and potential energy involved in the motion of a pendulum?5. Have students read and discuss the article on Foucault’s Pendulum.6. Have students calculate the speed of an amusement park pendulum ride based on the calculation for conservation of energy ($mgh = 0.5mv^2$). Have student explain the results of the calculation and use this data to create an advertisement for the ride in their new amusement park.7. Have students read the article on wall clocks synchronization.
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5. Crosscutting Concepts

<p>Current Crosscutting Concepts</p>	<p>Unifying Concepts and Processes (Crosscutting concepts) Listed in page viii of the front matter of the Arizona Science Standard, and explained in the National Science Education Standards (1995) pp. 115-119</p> <p>Systems, Order and Organization</p> <p>Consistency, Change, and Measurement</p>	<p>Gap Analysis Refer to the Crosscutting Concepts learning progressions within the Learning Progressions for 9-12 Science document and your current curriculum to answer the following questions.</p> <ul style="list-style-type: none">• How is/are the crosscutting concept(s) made explicit within my current curriculum?• What changes and refinements need to be made?• What strategies/investigations can be implemented to achieve the vision? <p>Systems and System Models Provide opportunities for students to model the system of a pendulum indicating the parts and the progression of movements.</p> <p>Energy and Matter Provide opportunities for students to understand that how the transfer of energy can be tracked during the movement of a pendulum.</p> <p>Vision of A Framework for K-12 Science Education</p>
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6. Connections

Other Content Area Standards	<p>Identify other Content Area Standards that will build student understanding of this concept or phenomenon, especially those in ELA/Literacy and Mathematics/Practices.</p> <p>RST.11-12.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.</p> <p>WHST.11-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.</p> <p>SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.</p> <p>MP.2 Reason abstractly and quantitatively.</p> <p>MP.4 Model with mathematics.</p> <p>HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.</p> <p>HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.</p> <p>HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.</p>	Connections to Instruction	<p>Gap Analysis Refer to the Other content standards that are being used as a connection to answer the following questions.</p> <ul style="list-style-type: none"> • How are the connected standards explicitly taught within my current curriculum? • What changes and refinements need to be made? • What strategies/investigations can be implemented to achieve the vision? <p>Reading Have students read an article on article on Foucault's Pendulum to determine the importance of this discovery and if it is still impacting the world today.</p> <p>Writing Can friction be a good thing? Have students wrote about this idea and cite specific examples of when it might be a good thing.</p> <p>Speaking and Listening Have students use digital media to model the period of a pendulum and explain their models to the class.</p> <p>Mathematics Have students mathematically calculate the period of a pendulum and explain the variables of the calculation including the correct units for each variable.</p> <p>Evaluate graphical representations of the simple harmonic motion of a pendulum.</p>
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